

Examination Scheme of MSc Biochemistry (Semester System)

From the academic session 2013-14

(Semester I)

S. No	Course no.	Title of Paper	Type	L-T-P	Credits	Evaluation Scheme		
						Theory	IA	Total Marks
1	BC 101	Biomolecules	PC	4-0-0	4	80	20	100
2	BC 102	Cell Biology	PC	4-0-0	4	80	20	100
3	BC 103	Enzymology	PC	4-0-0	4	80	20	100
4	BC 104	Human Physiology	PC	4-0-0	4	80	20	100
5	BCE 105 BCE 106	Biochemical Toxicology or Bioorganic chemistry	PE	3-1-0	4	80	20	100
6	BC107	Lab Course I		0-0-20	10	-	-	100

Total Credits: 30

Total Marks: 600

Semester –II

S. No	Course no.	Title of Paper	Type	L-T-P	Credits	Evaluation Scheme		
						Theory	IA	Total Marks
1	BC 201	Metabolism	PC	4-0-0	4	80	20	100
2	BC 202	Molecular Biology	PC	4-0-0	4	80	20	100
3	BC 203	Biophysical and Biochemical techniques	PC	4-0-0	4	80	20	100
4	BC 204	Immunology	PC	4-0-0	4	80	20	100
5	BCE 205	Genetics	PE	3-1-0	4	80	20	100
6	BCE 206	Environmental biology	PE					
7	BC 207	Lab Course II		0-0-20	10	-	-	100

Total Credits: 30

Total Marks: 600

To be implemented from the academic session 2014-15

Semester -III

S. No	Course no.	Title of Paper	Type	L-T-P	Credits	Evaluation Scheme		
						Theory	IA	Total Marks
1	BC 301	Plant Biochemistry	PC	4-0-0	4	80	20	100
2	BC 302	Nutritional Biochemistry	PC	4-0-0	4	80	20	100
3	BC 303	Clinical Biochemistry	PC	4-0-0	4	80	20	100
4	BC 304	Microbial Biochemistry	PC	4-0-0	4	80	20	100
5	BCE 305	Bioinformatics	OE	3-1-0	4	80	20	100
6	BC 306	Lab Course III Dissertation		0-0-20	10	-	-	100

Total Credits: 34

Total Marks: 600

Semester -IV

S. No	Course no.	Title of Paper	Type	L-T-P	Credits	Evaluation Scheme		
						Theory	IA	Total Marks
1	BC 401	Biostatistics	PC	4-0-0	4	80	20	100
2	BC 402	Methods in molecular biology	PC	4-0-0	4	80	20	100
3	BC 403	Seminar	--	0-0-0	1	50	-	50
4	BC 404	Dissertation (continued from 3 rd semester)	PC	0-0-48	24	-	-	300

Total Credits: 33
Total Marks: 550
Grand Total: 2350

M.Sc. Dissertation Rules (From session 2013-14)

Distribution/ Allotment of students: to be done at Departmental level but ratio of distribution to be done as per Ph.D. Seats i.e. in 8:5:3 ratio. The dissertation is to be Innovative work based on small piece of research with duration in 3rd and 4th semesters. Scheme of Chapters of dissertation is as follows-

Acknowledgement

Certificate by Supervisor

- (i) Introduction with objectives.
- (ii) Review of Literature (Brief)
- (iii) Materials & methods
- (iv) Results
- (v) Discussion
- (vi) Summary
- (vii) Bibliography

Pattern of References/Typing/Figures as per Ph.D. Thesis. Last date of submission will usually be 30th June. The evaluation of dissertation will be done by external examiner (Approved by the VC From panel approved by PGBOS) and internal examiner (Guide). Final marks will be mean of Internal + External.

The written part of Dissertation report shall account for 250 of marks and the viva-voce will be conducted by a duly constituted Board of Examiners for the remaining 50 of marks.

Dissertation report will be evaluated on the basis of below given criteria:

Performance Evaluation Parameter	Score
Writing Quality	50

Novelty/Scientific Significance of Aim	50
Project Design	50
Publication Potential	50
Aim-Results Concurrence	50

No. of copies of Dissertation will be- One copy for Deptt. record, One copy for Guide record, One copy for candidate and Soft copy to library. Any Patent/IPR based on Dissertation will be in the name of MDU student & Guide as inventor. Publication based on Dissertation will be under control of Guide.

BC 101: Biomolecules

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All five questions to carry equal (16) marks.

Max. Marks: 80

Max. Time: 3 hrs

UNIT 1

Introduction: Introduction to Biochemistry, water as biological solvent, weak acids and bases, pH, buffers, Handerson-Hasselbalch equation, physiological buffers.

Carbohydrates: Classification, structure, occurrence and biological functions. Glycoproteins. Physicochemical properties of monosaccharides.

UNIT 2

Lipids: Classification, structure, occurrence and biological functions of lipids. Nomenclature and properties of fatty acids and triglycerides, saponification number, acid number, Reichert-Meissel number, rancidity of fats. Composition and types of lipoproteins. Steroids and carotenoids of biological origin, liposomes.

UNIT 3

Amino acids: Nomenclature, classification and chemical structure of amino acids. Physicochemical properties of amino acids with their titration curve, reaction with ninhydrin, amino acids as zwitterions and isoelectric point.

Proteins: Classification, structure (primary, secondary, tertiary and quaternary; structure of peptide bond, Ramachandran Plot), properties and biological functions of proteins. Protein denaturation, renaturation. Methods to determine amino acid sequence- N- and C-terminal amino acid identification, Chemical synthesis of polypeptides, salting in and salting out of proteins.

UNIT 4

Nucleic acids: Nature of genetic material, properties of DNA insolution, evidence of DNA as genetic material and evidence for semi-conservative nature, Composition of RNA and DNA, generalized structure plan of nucleic acids, nomenclature in structure of nucleic acids, features of DNA double helix, denaturation and annealing of DNA. Structure and roles of different types of DNAs and RNAs.

Porphyryns: Porphyrin nucleus and classification of porphyrins, important metalloporphyrins occurring in nature, Chemical nature and significance of bile pigments.

Suggested Readings: _____.

1. Lehninger Principles of Biochemistry 4th Ed **By** David L. Nelson and Michael M. Cox, WH Freeman and Company.
2. Chemistry of Biomolecules: an Introduction (Paperback) **By** Richard J. Simmonds. Publisher: Royal Society of Chemistry
3. Principles of Biochemistry (Hardcover) **By** Geoffrey Zubay. Publisher: McGraw Hill College.
4. Biochemistry **By** Lubert Stryer. WH Freeman and Co.

5. Biochemistry: The Molecular Basis of Life (Paperback) **By** Trudy McKee and James R McKee. Publisher: McGraw-Hill Higher education.
6. Biochemistry and Molecular biology **By** William H. Elliott and Daphne C. Elliott. Oxford University Press.
7. Biochemistry (Hardcover) 3rd Ed. **By** Donald J. Voet and Judith G. Voet. John Wiley and Sons.
8. Biochemistry: Biomolecules, Mechanisms of Enzyme Action and Metabolism Vol 1 (Hardcover) **By** D Voet. John Wiley and Sons.
9. Fundamentals of Biochemistry: Life at the Molecular Level [Import] (Hardcover) **By** Donald Voet, Judith G. Voet and Charlotte W. Pratt. Publisher: Wiley.
10. Principles of Biochemistry (Paperback) **By** Robert Horton, Laurence A Moran, Gray Scrimgeour, Marc Perry and David Rawn. Pearson Education.
11. Biochemistry **By** U. S. Satyanarayana
12. Outlines of Biochemistry **By** Eric C Conn, PK Stumpf, G Bruening and Ray H. Doi. John Wiley & Sons.

BC 102: Cell Biology

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All five questions to carry equal (16) marks

Max. Marks: 80

Max. Time: 3 hrs

UNIT 1

The ultra structure and functions of nucleus, mitochondria (organization of ETC), endoplasmic reticulum, Golgi apparatus, lysosomes and peroxisomes. Processing of proteins in ER and Golgi. Ultrastructure of cell membrane with reference to RBC.

The epithelial apices- glycocalyx and microvilli. The basement membrane- structural features and characteristics. The extracellular matrix- collagen, elastin, fibrillin, fibronectin, laminin and proteoglycans.

UNIT 2

The cytoskeleton: microtubules and microfilaments, functions of motor proteins in microtubules. Secretory pathways in cell, cell-cell interactions (cadherins, integrins, IgSF, selectins, tight/gap junctions),

Transport proteins in cell membrane (channel proteins, passive carrier proteins, coupled transporters and ATP-driven pumps). Cell cycle- phases and regulation. Tissues, Classification and role of various type of tissues, organization of various tissues in organs.

UNIT 3

Chemical structure of gene and chromosome. Replication, transcription and translation (with regulation) in *eukaryotes*, Activators, repressors and insulators of transcription. Post-transcriptional modifications of mRNA and processing of pre-tRNA & pre-rRNA. Transport of processed mRNA. Inhibitors of replication, transcription and translation.

Turnover of RNA, protein targeting and degradation, Gene regulation in eukaryotes and prokaryotes, Operon concept, *Lac* operon, *Arab* operon and *Trp* operon,

UNIT 4

Receptors, Types of receptors, role of receptors in signal transduction, Mechanisms of signal transduction, Role of GTP in signal transductions; Mutations in DNA, mutagenicity testing and DNA repair mechanisms.

Role of signal transduction in immunological mechanisms. Biochemistry of cancer – carcinogenesis, characteristics of cancer cell, Prognosis of cancer, Classification of carcinogens, agents promoting carcinogenesis, biochemical markers in cancer.

Suggested Readings:_____.

1. Molecular Cell Biology 4th Ed **By** James E. Darnell, Harvey Lodish, Arnold Berk, and Lawrence Zipursky, W.H. Freeman and Co.
2. Molecular Biology of the Cell 4th Ed **By** Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter. Garland Publishers.
3. Cell Biology (Hardcover) **By** Thomas D. Pollard and William C. Earnshaw. Publisher: Saunders.
4. Cell and Molecular Biology: Concepts and Experiments (Hardcover) 5th Ed **By** Gerald Karp. John Wiley and Sons.
5. Cell and Molecular Biology **By** EDP de Robertis and EMF de Robertis (Jr.). Lippincott Williams & Wilkins, Philadelphia.
6. The Biochemistry of Cell Signalling **By** Ernst JM Helmreich, Oxford University Press.
7. Signal Transduction (Modular Texts in Molecular and Cell Biology) (Paperback) **By** C.H. Heldin, Carl-Heldin Heldin and Mary Purton. Bios Scientific Publishers Ltd.
8. Fundamental Neuroscience 2nd Edition **By** Larry Squire, James Roberts, Nicholas Spitzer, Michael Zigmond. Academic Press

BC 103: Enzymology

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All five questions to carry equal (16) marks.

Max. Marks: 80

Max. Time: 3 hrs

Unit 1

Introduction: History, general characteristics, nomenclature, IUB classification, definitions with examples of holoenzyme, apoenzyme, coenzymes, prosthetic groups, cofactors, activators, inhibitors, active site, metalloenzymes, isozymes, monomeric enzymes, oligomeric enzymes and multienzyme complexes. Units of enzyme activity, specific activity of enzyme, measurement of enzyme activity, Ribozymes and abzymes.

Enzyme Catalysis: Role of enzymes in energy of activation, factors of affecting action of enzymes- proximity and orientation, strain and distortion, acid base catalysis and covalent catalysis. Determination of active site. Mechanism of action of chymotrypsin, ribonuclease, carboxypeptidase and lysozyme.

Unit 2

Enzyme kinetics: Factors affecting enzyme activity- pH, temperature, time of incubation, enzyme concentration and substrate concentration. Derivation of Michaelis-Menten equation for unisubstrate reaction, K_{cat}/K_m and its significance, Lineweaver-Burk plot and its limitations; Eadie-Hofstee Plot, Eadie Plot, Hanes plot and Eisenthal-Cornish-Bowden plot. Significance and calculation of energy of activation from Arrhenius plot.

Reversible and irreversible inhibition; competitive, non-competitive and uncompetitive inhibitions with determination of K_m and V_{max} in presence of reversible inhibitor. Derivation of K_i and Dixon plot. Kinetics of multisubstrate reactions, introduction to sequential and ping-pong mechanisms and their classifications & double reciprocal plots with examples.

Unit 3

Protein-ligand binding, cooperativity phenomenon, Hill and Scatchard plots. Allosteric enzymes: Sigmoidal kinetics and their physiological importance, symmetric and sequential modes for action of allosteric enzymes and their significance.

Immobilization of enzymes: Introduction, classification, various methods of immobilization, kinetics of immobilized enzymes and its significance, applications of immobilized enzymes in analysis of biological materials, food industry and medicine.

Unit 4

Enzyme Regulation: Reversible and irreversible covalent modification, feedback inhibition, control of enzyme by products, substrates and adenylate energy charge, monocyclic and multicyclic cascade systems. Enzyme activation, induction and repression.

Coenzymes: Structure and biological functions of NAD, NADP, FAD, FMN, TPP, THF, biotin, Coenzyme Q, ascorbic acid, lipoic acid and PLP.

Suggested Readings: _____.

1. Fundamentals of Enzymology: Cell and Molecular Biology of Catalytic Proteins (Paperback) **By** Nicholas C. Price and Lewis Stevens. Oxford University Press.
2. Advances in Enzymology: v. 47 (Hardcover) **By** Alton Meister. John Wiley and Sons Inc.
3. Lehninger Principles of Biochemistry 4th Ed **By** David L. Nelson and Michael M. Cox, WH Freeman and Company.
4. Principles of Biochemistry (Hardcover) **By** Geoffrey Zubay. Publisher: McGraw Hill College.
5. Biochemistry: Biomolecules, Mechanisms of Enzyme Action and Metabolism Vol 1 (Hardcover) **By** D Voet. John Wiley and Sons.
6. Basic Biochemical Laboratory Procedures and Computing **By** R. Cecil Jack, Oxford University Press.
6. Enzyme Kinetics: Principles and Methods (Hardcover) **By** Hans Bisswanger. Publisher: Wiley VCH.
7. Enzymatic Reaction Mechanisms (Hardcover) **By** Perry A. Frey and Adrian D. Hegeman. Oxford University Press.
8. Comprehensive Enzyme Kinetics (Hardcover) **By** Vladimir Leskovic. Publisher: Kluwer Academic / Plenum Publishers.
9. Enzyme Kinetics: A Modern Approach (Hardcover) **By** Alejandro G. Marangoni. Publisher: WileyBlackwell.
10. Enzyme Kinetics and Mechanisms (Hardcover) **By** Kenneth B. Taylor. Kluwer Academic Publishers.
11. Nature of Enzymology **By** RL Foster
12. A textbook of enzyme biotechnology **By** Alan Wiseman.
13. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry **By** Trevor Palmer.
14. Enzymes **By** M Dixon and EC Webb. EC Longmans, London.
15. The chemical kinetics of enzyme action **By** KJ Laidler and PS Bunting. Oxford University Press, London.

BC 104: Human Physiology

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All five questions to carry equal (16) marks.

Max. Marks: 80

Max. Time: 3 hrs

UNIT 1

Blood- Composition and functions of plasma, hemopoiesis, erythrocytes including Hb, leukocytes and thrombocytes, plasma proteins and their role. Blood coagulation - mechanism and regulation, Fibrinolysis, Blood groups and Rh factor. Transfers of blood gases - oxygen and carbon dioxide. Role of 2, 3-BPG, Bohr effect and chloride shift. Regulation of respiration. Pulmonary circulation.

Digestive system- Composition, functions and regulation of salivary, gastric, pancreatic, intestinal and bile secretions. Digestion and absorption of carbohydrates, lipids, proteins, nucleic acids, minerals and vitamins. Role of peristalsis and large intestine in digestion.

UNIT 2

Resting potentials and action potentials of excitable cells, contraction of skeletal, cardiac and smooth muscles. Neurophysiology: Types of neurons and synapses and transmission of nerve impulse across them, Neurochemistry of vision, gustation, olfaction and hearing. Sensory receptors in skin and muscles.

Endocrinology- Secretion, mechanisms of action and effects of hormones of hypothalamus, pituitary, thyroid, adrenal gland and pancreas. Synthesis and functions of testosterone and ovarian hormones.

UNIT 3

Rhythmical excitation of heart, basic theory of circulatory function, blood flow and resistance, function of arterial and venous systems. Microcirculation and lymphatic system, control of blood flow, regulation of arterial pressure, cardiac output.

Spinal cord and motor functions, role of brain stems in controlling motor functions, functions of cerebellum, functions of cortical areas, the limbic system and cerebrospinal fluid system.

UNIT 4

Excretory system- Structure of nephron, formation of urine (glomerular filtration, tubular reabsorption of glucose, water and electrolytes), tubular secretion, role of kidneys regulation of blood pressure.

Control of body temperature, effect of low oxygen pressure on body, effects of acceleratory forces on body, effects of high partial pressures of gases on body

Suggested Readings:_____.

1. Textbook of Medical Physiology 10th Ed **By** Arthur C. Guyton and John E. Hall, Harcourt Asia Pte Ltd.
2. Essential Medical Physiology 3rd Ed **By** Leonard R. Johnson, Elsevier Academic Press.
3. Endocrinology: An Integrated Approach **By** SS Nussey and SA Whitehead. BIOS Scientific Publishers
4. Physiology 3rd Ed, **By** Linda Costanzo, Saunders Publishers.
5. Principles of Anatomy and Physiology 10th Edition **By** Gerard J. Tortora and Sandra Grabowski. Publisher: John Wiley and Sons.
6. Principles of Human Physiology (Paperback) **By** Cindy L. Stanfield and William J. Germann. Publisher: Pearson Education.
7. Samson Wright's Applied Physiology 13th Ed. CA Keele, E Neil & N Joels. Oxford University Press.
8. Principles of Biochemistry: Mammalian Biochemistry **By** Emil Smith. McGraw Hill Publications.
9. Human Physiology: The Mechanisms of Body Function (Paperback) **By** Arthur J. Vander, James Sherman, Dorothy S. Luciano, Eric P. Widmaier, Hershel Raff and Hershal Strang. McGraw Hill Education.
10. Medical Physiology: Principles for Clinical Medicine 3rd Ed. **By** Rodney R. Rhoades and David R. Bell. Lippincott Williams & Wilkins.

BCE 105: Biochemical Toxicology

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All questions to carry equal marks.

Max. Marks: 80

Max. Time: 3 hrs

PROGRAM ELECTIVE

UNIT 1

Definition and Scope of Toxicology: Dose-response relationship, synergism and antagonism, determination of ED₅₀ & LD₅₀, acute and chronic exposure; clinical signs of systemic toxicity.

Xenobiotic metabolism: absorption & distribution, phase I reactions; oxidation, reduction, hydrolysis and hydration; phase II reactions/conjugation; methylation, glutathione and amino acid conjugations, detoxification.

UNIT 2

Biochemical basis of toxicity: Biochemical and Genetic mechanism of toxicity, Mutagenesis, Cellular and organ malfunction caused by toxic compounds.

Toxicity testing: genetic toxicity testing & mutagenesis assays - bacterial mutation tests, reversion test, ames test and fluctuation tests; *in vivo* mammalian mutation tests-host mediated assay & dominant lethal test.

UNIT 3

Pesticide toxicity: Insecticides and their classification, mode of action, Insecticides- anti-cholinesterases insecticides, role of biopesticides in environmental management.

Metal toxicity: Toxicity of Arsenic, Mercury, Lead, Chromium and Cadmium; various factor effecting respective toxicity.

UNIT 4

Food toxicology: Role of diet in cardio-vascular diseases and cancer; Toxicology of various types of food additives

Diagnosis of toxic changes in liver and kidney: Metabolism of haloalkanes, haloalkenes and paracetamol with their toxic effects on tissues.

Suggested reading:-

1. General and applied toxicology, 1995 by Marrs and Turner Macmillan Press Ltd
2. Basic environmental toxicology 1994 by Lorris G. Corkerhem and Barbara SS
Shane CRP Press Inc.
3. Introduction to food technology Takayurki Shibamoto & Leonard F. Bzeldanes
4. Molecular biotechnology 2nd Ed 1994 by Barnard R Glick & JJ Pasternak

BCE 106: Bioorganic Chemistry

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All questions to carry equal marks.

Max. Marks: 80

Max. Time: 3 hrs

PROGRAM ELECTIVE

UNIT 1

Organic Chemistry: Electronic theory of valency, dipole moments. Electronic displacements in a molecule: Inductive effect, electronic effect, resonance. The hydrogen bond, hydrophobic interactions. Atomic and molecular orbitals. Hybridization and tetravalency of carbon.

Types of organic reactions: Substitution, addition, elimination, rearrangement, condensation and polymerization.

UNIT 2

Free radicals in biological systems: Various processes for free radical formation in living system; oxygen as a free radical in the auto oxidation of fats.

Mechanism of substitution in the benzene ring: o-,p- and m- directing groups. The concept of resonance with reference to benzene derivatives. Direct influence of substituents-electronic interpretation.

UNIT 3

Isomerism: Structural isomerism, stereoisomerism, geometrical isomerism (E&Z nomenclature)

Stereochemistry: Optical isomerism, optical activity, meso-compounds, specific rotation, chirality, chiral center, enantiomers, diastereoisomers, D L, R S, thero erythro notations, conformation and configuration, dihedral angles, conformational analysis of ethane, n-butane, cyclohexane, mono and di-substituted cyclohexane, monosaccharides, boat and chair forms, eclipsed, gauche and staggered confirmations, axial and equatorial bonds. Anomers and mutation, glycoside, epimers, glucopyranose, fructopyranose, periodic acid oxidation of sugars.

UNIT 4

Heterocyclic systems occurring in living systems: numbering of ring and properties of pyran, furan, thiazole, indole, pyridine, pyrimidine, quinine, purine and pteridine.

Electrochemistry: Types of electrodes, standard electrode potential and its determination, its relationships with emf, electron transfer measures. Phosphate group transfer potentials, coupled reactions.

BC 107: Lab Course I

Max. Marks: 100

Max. Time: 3 hrs

Preparation of Buffers and various biochemical reagents, Calculations of Normality and molarity of the reagents, pH estimations, Weighing of reagents, Preparation of distilled water, Autoclaving, cleaning and sterilization of reagents.

Preparation of glucose standard curve, Estimation of glucose in biological fluids using various biochemical methods, Estimation of other carbohydrates

Isolation of lipids from various samples, Biochemical assays for identification of lipids (acid value, saponification number, iodine number), separation of lipids using thin layer chromatography (TLC) and paper chromatography (PC).

R_f value calculation of various amino acids using TLC & PC, Biochemical assays for protein estimations (Bradford and Lowry methods).

BC 201: Metabolism

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All questions to carry equal marks.

Max. Marks: 80

Max. Time: 3 hrs

UNIT 1

Introduction: Concept of metabolism, experimental approaches to study metabolism- use of intact organisms, bacterial mutants, tissue slices and radioisotopes.

ETC and Oxidative phosphorylation: Sequence of electron carriers, sites of ATP production, inhibitors of ETC, mechanism and regulation of mitochondrial oxidative phosphorylation, ATP synthase (mitochondrial vs. bacterial), uncouplers of oxidative phosphorylation, transport of reducing potential and ions across mitochondrial membrane, microsomal electron transfers, generation of superoxides in mitochondria.

UNIT 2

Carbohydrate Metabolism: Reactions and energetics of glycolysis. Alcoholic and lactic fermentations, entry of fructose, mannose and galactose. Reactions and energetics of TCA cycle, gluconeogenesis, glycogenesis and glycogenolysis. Reactions and physiological significance of HMP pathway, regulation of glycolysis and gluconeogenesis, cataplerosis and anaplerosis, biosynthesis of starch and oligosaccharides, regulation of blood glucose. Uronic acid pathway and glyoxylate cycle.

Amino acid metabolism: General reactions of amino acid metabolism- transamin-ation, deamination and oxidative decarboxylation. Biosynthesis and degradation of amino acids and their regulation. Feedback regulation of amino acid biosynthesis. Urea cycle and its regulation.

UNIT 3

Lipid catabolism: Transport and mobilization of lipids, oxidation of saturated fatty acids, oxidation of unsaturated and odd-chain fatty acids, role of carnitine in transport of fatty acids, energetics of oxidation reactions, metabolism of ketone bodies and its biological significance.

Lipid anabolism: Biosynthesis of saturated and unsaturated fatty acids. Biosynthesis of triglycerides, phospholipids, sphingolipids and cholesterol. Regulation of cholesterol metabolism. Metabolism of lipoproteins. Biosynthesis of prostaglandins.

UNIT 4

Nucleic acid Metabolism: Sources of atoms in purine and pyrimidine molecules, biosynthesis and degradation of purines and pyrimidines, regulation of purine and pyrimidine biosynthesis, structure and regulation of ribonucleotide reductase.

Biosynthesis of ribonucleotides, deoxyribonucleotides and polynucleotides. Inhibitors of nucleic acid biosynthesis. Porphyrin Metabolism: Biosynthesis and degradation of porphyrins, production of bile pigments.

Suggested Readings:

1. Lehninger Principles of Biochemistry 4th Ed **By** David L. Nelson and Michael M. Cox, WH Freeman and Company.
2. Principles of Biochemistry (Hardcover) **By** Geoffrey Zubay. Publisher: McGraw Hill College.
3. Harper's Biochemistry (Lange Medical Books) (Paperback) **By** Robert K. Murray, Daryl K. Granner, Peter A. Mayes and Victor W. Rodwell. Publisher: Appelton and Lange.
4. Bioenergetics **By** David G. Nicholls and Stuart J. Ferguson. Academic Press.
5. Bioenergetics at a Glance: An Illustrated Introduction (At a Glance) (Paperback) **By** D. A. Harris. Publisher: Wiley Blackwell
6. Bioenergetics: 0 (Paperback) **By** Lars Garby and Poul S. Larsen. Cambridge University Press.
7. Fundamentals of Biochemistry: Life at the Molecular Level [Import] (Hardcover) **By** Donald Voet, Judith G. Voet and Charlotte W. Pratt. Publisher: Wiley.
8. Biochemistry (Hardcover) 3rd Ed. **By** Donald J. Voet and Judith G. Voet. John Wiley and Sons.
9. Biochemistry of Lipids, Lipoproteins and Membranes (4th Ed.) D.E. Vance and J.E. Vance. Pub: Elsevier Science B.V
10. Medical Biochemistry 4th Ed. by NV Bhagavan. Pub: Elsevier India Pvt. Ltd.
11. Biochemistry: Biomolecules, Mechanisms of Enzyme Action and Metabolism Vol 1 (Hardcover) **By** D Voet. John Wiley and Sons.
12. Biochemistry **By** Lubert Stryer. WH Freeman and Co.
13. Principles of Biochemistry (Paperback) **By** Robert Horton, Laurence A Moran, Gray Scrimgeour, Marc Perry and David Rawn. Pearson Education.
14. Harper's Biochemistry **By** RK Murray, DK Granner, PA Mayes and VW Rodwell. Appelton and Lange, Stanford.
15. Biochemistry **By** U. S. Satyanarayana
16. Outlines of Biochemistry **By** Eric C Conn, PK Stumpf, G Bruening and Ray H. Doi. John Wiley & Sons.

BC 202: Molecular Biology

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All questions to carry equal marks.

Max. Marks: 80

Max. Time: 3 hrs

UNIT 1

Enzymes used in molecular cloning (restriction enzymes, DNA-Polymerases, ligases, kinases, phosphatases, and nucleases); methods of production of recombinant DNA; construction of DNA libraries- genomic vs. cDNA library; Screening methods for genomics/cDNA libraries, chemical synthesis of gene; Cloning vectors like- λ -phage, plasmids, cosmid, fosmid, BAC and YAC and their characteristics. Shuttle vectors and expression vectors (Characteristics and applications)

Proteins production in *E. coli* & yeast. Applications of recombinant DNA, Site directed mutagenesis, RAPD, RFLP & DNA finger printing, DNA Foot Printing, Mobility shift assay, Reporter assay, Yeast Two hybrid systems, antisense-RNA technology, chromosomal walking, gene therapy and recombinant vaccines.

UNIT 2

Rapid DNA sequencing techniques: Sanger's dideoxynucleotide, Maxam and Gilbert's method, pyrosequencing and single molecule sequencing with exonuclease. Analysis of DNA by Southern hybridization

Extraction, purification and analysis of mRNA from eukaryotic cells; RNA sequencing techniques (Direct chemical sequencing, enzymatic sequencing and sequencing of HMW RNAs by reverse transcriptase). Analysis of RNA by Northern Hybridization

UNIT 3

Somatic cell culture- animal cell and Plant cell culture; Protoplast isolation, protoplast fusion & protoplast culture. Micropropagation- Stages, application and limitations.

Genetic Engineering: production of gene constructs, various methods of gene transfer (viral vectors, transfection/direct gene transfer, agrobacterium mediated gene transfer, targeted gene transfer). Uses of transgenics in development of insect and virus resistance in plants.

UNIT 4

Fermentation Technology: Primary and secondary metabolites in biotechnology, continuous and batch type culture techniques,

Emerging trends in Molecular Biology: *In Vivo* Mutation strategies; SAGE, Transcription profiling, De Novo Genome Sequencing; Metabolomics, Meta proteomics, Metagenomics.

Suggested Readings: _____.

1. Basic Biotechnology (Paperback) *By* Colin Ratledge and Bjorn Kristiansen. Cambridge University Press.

2. Introduction to Biotechnology (Paperback) **By** William J. Thieman and Michael A. Palladino. Benjamin Cummings; US Ed edition.
3. DNA Repair and Mutagenesis, **By** Errol C. Friedberg, Graham C. Walker, Wolfram Siede. ASM Press.
4. Recombinant DNA Principles and Methodologies **By** James Joseph Greene, CRC Press.
5. Molecular Biotechnology: Principles and Applications of Recombinant DNA (Paper-back) **By** Bernard J Glick and Jack J Pasternak. Publisher: American Society for Microbiology.
6. Molecular Cloning: a laboratory manual (Vol 1, 2 & 3) **3rd Ed. By** J. Sambrook and DW Russel. Cold Spring Harbor Laboratory Publications, NY
7. Laboratory Techniques in Biochemistry and Molecular Biology; DNA sequencing (Vol 10). **By** J Hindley. Elsevier Biomedical.
8. Methods of DNA and RNA sequencing. **By** Sherman M. Weissman. Pub: Praeger
9. RNA isolation and analysis **By** P. Jones, J Qiu and D. Rickwood. Bios Scientific Publishers.
10. Advanced Organic Chemistry of Nucleic Acids (Paperback) **By** Zoe A. Shabarova and Alexey A. Bogdanov. Pub: VCH Publishers, Inc., New York, NY (USA).
11. Analytical Techniques in DNA sequencing **By** Brian Nunnally. Pub: Taylor and Francis.
12. Gene Cloning and DNA Analysis: An Introduction (Paperback) **By** Terence. A. Brown. WileyBlackwell.
13. Gene Cloning: An Introduction (Paperback) **By** Terence A. Brown. Nelson Thornes Ltd.
14. Principles of Gene Manipulation and Genomics, **By** S.B. Primrose & Richard M. Twyman, Blackwell Publishing.
15. Principles of Fermentation Technology (Paperback) **By** P F Stanbury, A. Whitaker and S. Hall. Publisher: Butterworth-Heinemann.
16. Biochemical Engineering and Biotechnology **By** Ghasem D. Najafpour. Publisher: Elsevier Science
17. Plant Propagation by Tissue Culture 'Vol 1' **By** Edwin George, Michael Hall and GJ de Klerk, Pub: Springer.
18. Biotechnology: A textbook of Industrial Microbiology, **By** Wulf Crueger and Thomas D. Brock. Sinauer Assoc.
19. Molecular Biology of the gene **By** J Watson, NH Hopkin, JW Roberts, JP Stertz and AM Weiner. WH Freeman and Co., San Fransisco.
20. Gene IX **By** Benjamin Lewin. Oxford University Press.
21. Biotechnology: Expanding Horizons **By** B. D. Singh, Kalyani Publishers.
22. Textbook of Biotechnology **By** PK Gupta, Rastogi Publications.
23. Biotechnology **By** U. Satyanarayana.
24. Advances in Biotechnology **By** Prof. SN Jogdand, Himalaya Publishing House

BC 203: Biophysical and Biochemical Techniques

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All questions to carry equal marks.

Max. Marks: 80

Max. Time: 3 hrs

UNIT 1

Bioenergetics: Laws of thermodynamics, concept of free energy, determination of G, relation between equilibrium constant and standard free energy change, entropy, biological oxidation and reduction reactions, energy rich compounds, thermodynamics of ion gradients

Radioisotope techniques: Isotopes and nature of radioactivity, types of radioactive decay, half-life. Measurement of radioactivity, uses of radioisotopes in research; In vivo and in vitro labeling techniques- double labeling, quenching, internal standard ratio and external standard ratio; autoradiography.

UNIT 2

Electrophoretic techniques: Theory of electrophoresis; continuous and discontinuous PAGE, SDS-PAGE; western blotting, Agarose-gel electrophoresis of DNA and RNA, Other electrophoretic methods - isoelectric focusing, 2-dimensional gel electrophoresis, capillary electrophoresis and PFGE

Chromatography Techniques: Adsorption vs. partition chromatography. Principle and applications of Paper, Thin layer chromatography, ion exchange, reverse phase, gel filtration, affinity, HPLC and gas chromatographic techniques.

UNIT 3

Basic principle of electromagnetic radiation: wavelength, wave number, frequency; Beer Lambert's law, absorbance and transmittance, calorimetry, flame photometry.

Spectroscopy: Basic concepts and applications of x-ray diffraction, principles and applications of UV-Visible, Fluorescence, NMR, ESR, mass spectrometry, ORD and CD spectroscopy.

UNIT 4

Viscosity & Centrifugation: Principle and applications of Viscosity, Measurement of viscosity by Ostwald's viscometer, Basic principle of sedimentation, factors affecting sedimentation, Instrumentation of centrifugation – low speed and high speed centrifuges, Ultracentrifuges, differential and density gradient centrifugation.

Microscopy: Light, electron (scanning and transmission), phase contrast and fluorescence microscopies. Preparation of specimen for electron microscopy and immunohistochemistry; marker enzymes.

Suggested Readings:_____.

1. Bioenergetics, 3rd Edition, **By** David G. Nicholls and Stuart J. Ferguson. Publisher: Academic Press.
2. Biophysics, 5th Edition, **By** R. Glaser, Springer, Netherlands
3. Principles and Techniques of Biochemistry and Molecular Biology **6th Ed.** Keith Wilson & John Walker, Cambridge University Press
4. Encyclopedia of Spectroscopy and Spectrometry (3-Volume Set with Online Version) (Hardcover) **By** George E. Tranter, John L. Holmes and John C. Lindon, Academic Press
5. Methods in Modern Biophysics, 2nd Edition, **By** Bengt Nolting, Springer Netherlands
6. Biophysical Chemistry: Principles & Techniques Handbook **By** Avinash Upadhyay, Kakoli Upadhyay and Nirmalendu Nath, Himalaya Publishing House.
7. Microbiology (Hardcover) **By** Lansing M. Prescott, John P Harley and Donald A. Klein. Publisher: McGraw Higher Education.
8. Chromatography: Concepts and Contrasts (Hardcover) **By** James M. Miller, Wiley, Interscience
9. Modern Experimental Biochemistry 3rd Edition, **By** Rodney Boyer, Benjamin Cummings Press.
10. Methods in Molecular Biology: Organelle proteomics, **By** Delphine Pflieger and Jean Rossier. Publisher: Humana Press
11. Biochemical Techniques: Theory and Practice **By** John F Roby. Publisher: SOS Free Stock.
12. Introduction to Electron Microscopy for Biologists: Methods in Cell Biology (Hardcover) **By** Terry D. Allen. Academic Press.
13. Enzyme and Microbial Biosensors: Techniques and Protocols (Methods in Biotechnology) (Hardcover) **By** Ashok Mulchandani. Humana Press Inc., U.S.

BC 204: Immunology

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All questions to carry equal marks.

Max. Marks: 80

Max. Time: 3 hrs

UNIT 1

Introduction to Immune System: Innate and acquired immunity, active and passive immunity, Immunological memory, self vs non-self discrimination, adjuvants in immune response. Cells & organs Involved in Immune Responses: Phagocytic cells and their killing mechanisms; T and B lymphocytes; Differentiation of lymphoid cells. Structure and functions of primary and secondary lymphoid organs.

Nature of Antigen and Antibody: Antigen vs Immunogen, Haptens; General organization of immunoglobulin, properties and functions of various types of immunoglobulins. Isotypic, allotypic and idiotypic variations of immunoglobulins.

UNIT 2

Generation of Diversity in Immune System: Clonal selection theory, Organization and expression of immunoglobulin genes- generation of antibody diversity. T cell receptor diversity. Major Histocompatibility Complex (MHC) Genes and Products: Role of MHC antigens in immune responses. MHC antigens in transplantation.

Humoral and Cell Mediated Immune Responses: Kinetics of primary and secondary immune response. Complement activation and its biological consequences. Antigen processing and presentation. Cytokines and costimulatory molecules: Role in immune responses. T and B cell interactions.

UNIT 3

Antigen-Antibody Interactions: Nature and kinetics of antigen-antibody interactions. Applications: Production of monoclonal antibodies, agglutination and precipitation techniques, radioimmunoassay, ELISA, Western blotting and immunofluorescence. Flow cytometry of cells complexed with tagged antibodies. Immunoelectron microscopy.

Tolerance vs Activation of Immune System: Immunotolerance, Immunosuppression, Hypersensitivity (Types I, II, III and IV).

UNIT 4

Immune Responses in Diseases: Immune responses to infectious diseases: viral, bacterial and protozoal. Cancer and immune system. Immunodeficiency disorders. Autoimmunity.

Immunization: Active immunization (immunoprophylaxis), Passive immunization (Immunotherapy) and role of vaccines in the prevention of diseases.

Suggested Readings:_____.

1. Fundamental Immunology (Hardcover) **By** William E. Paul. Publisher: Lippincott Williams and Wilkins.
2. Immunology: International Edition (Paperback) **By** Janis Kuby, Thomas J. Kindt, Barbara A. Osborne and Richard A. Goldsby. WH Freeman and Co. Ltd.
3. Immunology (Paperback) **By** Richard A. Goldsby, Thomas J. Kindt, Barbara A. Osborne and Janis Kuby. WH Freeman and Co. Ltd.
4. Immunology (Paperback) **By** Ivan M. Roitt, Jonathan Brostoff and David Male. Publisher: Mosby.
5. Introduction to Medical Immunology **By** Gabriel Virella, Marcel Dekker Inc.
6. Roitt's Essential Immunology **By** Ivan M. Roitt and Peter J. Delves, Blackwell Publishing
7. Understanding Immunology (Cell and Molecular Biology in Action) (Paperback) **By** Peter Wood. Publisher: Prentice hall.
8. Basic Immunology: The Functions of the Immune System (Paperback) **By** Abul K. Abbas and Andrew H. Lichtman. Publisher: Saunders.
9. A Handbook of Practical Immunology, **By** G. P. Talwar, Pub: Vikas Publishing House.
10. Fundamental Immunology (Hardcover) **By** Robert M. Coleman and M.F. Lombard. Publisher: Brown (William C.) Co , U.S.
11. Atlas of Immunology (Hardcover) **By** J.M. Cruse (Author), Robert E. Lewis. CRC Press Inc.
12. Immunology **By** Edwards S Golub. Sinauer Associate, Sunderland.

BCE 205: Genetics

PROGRAM ELECTIVE

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All questions to carry equal marks.

Max. Marks: 80

Max. Time: 3 hrs

UNIT 1: Basics of Genetics

Mendelian laws, Applications of probability tests and chi-square test. Gene interactions, Chromosomal basis of inheritance. Multiple alleles, lethal alleles and penetrance & expressivity. Interaction of genes with environment.

Pleiotropy, Sex determination, Multiple sex chromosomes. Sex linked, sex- limited and sex influenced traits. Cytoplasmic inheritance.

UNIT 2: Crop and Livestock Genetics

Techniques of plant breeding- modern breeding methods. QTL analysis and functional genomics for crop improvement. Applications of molecular markers in crop improvement. Use of mutation breeding.

Methods of livestock improvement, animal breeding systems, breeding for productivity, marker assisted breeding, economically important loci. Inter and intraspecies DNA transfer

UNIT 3: Evolutionary Genetics and Gene mapping

Speciation concept, modes of speciation, Molecular clock and evolution, Allele and genetic variations, Sources of variations: Hardy-Weinberg principles and its applications.

Mitochondrial DNA polymorphism. Y-chromosome polymorphism and Single nucleotide polymorphism (SNP), Physical and genetic mapping, Gene mapping by in-situ hybridization, Isolation of individual chromosomes, Linkage analysis and genetic maps, Linkage equilibrium and disequilibrium.

UNIT 4: Human Genetics

Human genome sequence and variations. Genetic counseling, Methods for diagnosis of genetic disorders, prenatal genetic evaluation, Genetics of personality, Intellectual disability. Genetics of Autism.

Heritable chromosomal abnormalities, Incidence of chromosome aberrations, Disorders of autosomes, Disorders of sex chromosomes, Disorders of sexual differentiation, Chromosome breakage syndromes.

Suggested Readings: _____.

1. Principles of Genetics **By** Gardner E.J, Simmons, M.J. & Snustad, D.P. John Wiley & Sons Inc, N.Y

2. Essentials of Genetics, 2nd Ed. **By** William S. Klug & Michael R. Cummings 1996. Prentice Hall Internationals
3. Essential Genetics, 2nd Ed. **By** Daniel L. Hartl & Elizabeth W. Jones, 1999. Jones & Bartlett Publishers
4. Molecular Techniques in Crop Improvement **By** S. Mohan Jain and DS Brar. Springer
5. Plant Breeding and Biotechnology **By** Denis Murphy. Cambridge
6. Modern Livestock and Poultry Production **By** James R. Gillespie and Frank B. Flanders. Delmar Cengage Learning.
7. Biotechnology for Livestock Production **By** Food and Agricultural Organization. Plenum Press.
8. Evolutionary Quantitative Genetics **By** Derek A. Roff. Chapman & Hall.
9. Evolutionary Genetics- From Molecules to Morphology **By** R. S. Singh & C. Krimbas. Cambridge University Press.
10. Human genetics: The molecular evolution **By** Edwin H. Mcconkey. Jones and Barlett Publishers.
11. Human Molecular Genetics (2nd Edition) **By** Tom Strachan & Andrew P.Read John Wiley & Sons.
12. Human Genetics-Concepts & Applications (3rd Edition) **By** Ricki Lewis. McGraw-Hill.
13. Vogel and Motulsky's Human Genetics **By** MR Speicher, SE Antonarakis and AG Motulsky. Springer
14. Human Genetics: From molecules to medicine **By** Christian P. Schaaf, Johannes Zschocke and Lorraine Potocki. Lippincott Williams & Wilkins.

BCE 206: Environmental Biology

PROGRAM ELECTIVE

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All five questions to carry equal (16) marks.

Max. Marks: 80

Max. Time: 3 hrs

Unit I

Definition, principles and scope of ecology, human ecology and human settlements, evolution, origin of life and speciation, Ecosystem stability-cybernetics and ecosystem regulation, demographies & survivorship curves, population growth, r & k selection, population limiting factors, community interactions & predation

Unit II

Ecosystem structure and functions, abiotic and biotic component, Energy flow, food chain, food web, Productivity & Chemical cycles, Ecological Pyramids-types, biogeochemical cycles, ecological succession, carbonate system, unsaturated and saturated hydrocarbons, Radionuclides

Unit III

Classification of elements, chemical speciation, Particles, ions and radicals in the atmosphere. Chemical processes for formation of inorganic and organic particulate matter. Thermochemical and photochemical reactions in the atmosphere. Transport of toxicants in environment, equilibrium partitioning, transformation processes

Unit IV

Oxygen and ozone chemistry, Chemistry of air pollutants, Photochemical Smog, Chemistry of water, concept of D.O., B.O.D., and C.O.D, water treatment: Sedimentation, Coagulation, Filtration, tertiary and advanced treatment, redox potential. Inorganic and organic components of soil; Intentionally added chemicals in foodstuffs- colors & adulterants; non-intentional food contaminants- mycotoxins, metals, PAH, pesticides.

References

1. Basic ecology - E. P. Odum
2. Ecology and field biology - R.L. Smith

3. Ecology - P.D. Sharma
4. Fundamentals of ecology -E.P. Odum
5. Principles of ecology – Rickleff
6. Environmental Chemistry - G.S. Sodhi
7. Environmental Chemistry - Mannhan
8. Fundamantals of soil science - Henry D. Futh
9. Environmental Chemistry - Sharma and Kaur

BC 207: Lab Course II

Max. Marks: 100

Time: 3hrs

Qualitative and quantitative determination of RNA and DNA, Standard curve preparation of DNA & RNA, Isolation of DNA from blood/bacteria/plant, Agarose gel electrophoresis, Polymerase chain reaction. RFLP

Protein purification techniques; Qualitative and quantitative test for proteins etc.; native and SDS PAGE, Western Blotting

Antigen-Antibody assay, ELISA tests, Immunoelectrophoresis, immunoprecipitation

Enzyme extraction and kinetic assays:- tests for optimum pH, time, temperature, activator, K_m and V_{max} , K_i .

BC 301: Plant Biochemistry

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All questions to carry equal marks.

Max. Marks: 80

Max. Time: 3 hrs

Unit 1

Structure and functions of plant cell (including cell wall, plasmodesmata, vacuoles & secretory systems). Isolation of cell organelles with assessment of chloroplast fraction purity. Absorption and transport of water and ions in plants. Evapotranspiration.

Biological nitrogen fixation and ammonia assimilation. Importance of Hup⁺ symbionts. Structure and properties of symbiotic nodules. Nitrate and sulfate reduction and their incorporation in amino acids. Electron allocation coefficient of nitrogen.

Unit 2

Photosynthesis: Overview of organelles involved in photosynthesis in plants and bacteria (including light receptors, chlorophyll, light harvesting complex). Bacteriorhodopsin as ion pump. Molecular change in chlorophyll by light. Quantum yield and quantum efficiency

Photosystems I & II- their location. Mechanism of quantum capture and energy transfer in photosystems- roles of ferredoxin, plastocyanin, plastoquinone, carotenoids. The Hill reaction and photophosphorylation. Reduction of carbon dioxide: C₃, C₄ and CAM metabolism with regulation (light activation of enzymes in them). Starch and sucrose metabolism. Role of inhibitors (DCMU) in photosynthetic electron transport. Photorespiration and its efficiency.

Unit 3

Functions of important growth regulating substances- brassinosteroids, oxylipins, salicylic acid, oligosaccharines and polyamines. Functions and molecular mechanisms of auxins, gibberellins, abscisic acid and cytokinins. Role of ethylene in fruit ripening.

Photoperiodism- phytochromes, cryptochromes and their physiological significance. Physiology of senescence. Biochemistry of seed development (including starch synthesis) and seed germination. Seed dormancy- its mechanism, types and uses. Biochemistry of fruit ripening. Artificial seeds-preparation and uses.

Unit 4

Defense system in plants against biotic stresses- roles of phytoanticipins, NADPH oxidase, defense proteins, NO, phenolic compounds, jasmonic acid, ethylene and phytoalexins. Resistance to virus by gene silencing. Genetic basis of pathogen resistance and effects of phytotoxins on plants. Biochemistry of herbicide action.

Biochemistry of plant under various abiotic stress conditions- Defense by antioxidant enzymes and non-enzymatic antioxidants. Stress physiology of salinity, water deficit, oxygen deficit, oxidative stress, temperature stress and heavy metal stress.

Suggested Readings:_____.

1. Biochemistry and molecular biology of plants **By** Bob B. Buchanan, Wilhelm Gruissem and Russel L. Jones, IK International Pvt. Ltd.
2. Plant Physiology, 4th Ed., **By** Lincoln Taiz and Eduardo Zeiger, Sinauer Associates Inc.
3. Introduction to Plant Physiology (Hardcover) **By** William G. Hopkins, Wiley Interscience.
4. Advances in Plant Physiology Series (Volumes 1-25), Pub: Springer Science
5. Plant Toxicology **By** Bertold Hock and Erich Elstner, Marcel Dekker.
6. Plant Hormone Signaling **By** Peter Hedden and Stephen Thomas, Blackwell Publishing.
7. Integrative Plant Biochemistry: 40 (Recent Advances in Phytochemistry) (Hardcover) **By** John Romeo. Elsevier Science.
8. Plant Biochemistry (Paperback) **By** PM Dey and JB Harborne. Academic Press Inc., US.
9. Plant Physiology, Biochemistry and Molecular Biology (Hardcover) **By** David T. Dennis and David H. Turpin. Publisher: Longman
10. Plant Biochemistry and Molecular Biology (Hardcover) **By** Hans-Walter Heldt. Oxford University Press.
11. Physiology and Molecular Biology of Stress Tolerance in Plants (Hardcover) **By** K.V. Rao Madhava, A.S. Raghavendra and K. Janardhan Reddy. Kluwer Academic Publishers.
12. Plant Biochemistry (Paperback) **By** Caroline Bowsher, Martin Steer and Alyson Tobin. Garland Publishing Inc., US.
13. Plant Physiology and Biochemistry (Paperback) **By** H.S. Srivastava and N. Shankar. Rastogi Publications.
14. Textbook of Plant Physiology, Biochemistry and Biotechnology (Paperback) **By** S. Verma and Mohit Verma. S. Chand and Co.
15. Plant Biochemistry (Hardcover) **By** Hans-Walter Heldt. Academic Press.

BC 302: Nutritional Biochemistry

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. All questions to carry equal marks.

Max. Marks: 80

Max. Time: 3 hrs

UNIT 1

Basic concepts: Concept of balanced diet and energy content of foods; Measurement of energy expenditure - Direct and indirect calorimetry; BMR, SDA and factors affecting them; Thermogenic effects of foods; Antinutrients; Nutraceuticals.

Carbohydrates: Dietary requirements and sources of available and unavailable carbohydrates. Physico-chemical properties and physiological actions of unavailable carbohydrates (dietary fibers); Glycemic index.

Proteins: Nitrogen balance studies and factors influencing nitrogen balance, Biological value of protein (B.V), protein efficiency ratio (PER), Essential amino acids and concept of protein quality, Cereal proteins and their limiting amino acids.

UNIT 2

Lipids: Chemical composition and distribution, Major classes of dietary lipids, composition and metabolism of lipoproteins Essential fatty acids and their physiological functions.

Electrolytes and pH balance: Electrolyte concentrations of body fluids, acid-base regulation in human body. Concept of metabolic and respiratory acidosis and alkalosis.

Minerals: Nutritional significance of dietary calcium, phosphorus, magnesium, iron, iodine, zinc and copper.

UNIT 3

Vitamins: Dietary sources, biochemical functions and specific deficiency diseases associated with fat and water soluble vitamins. Hypervitaminosis symptoms of fat-soluble vitamins. Nutritional requirements of vitamins for infants & children and during pregnancy and lactation.

Nutritional disorders: Etiology, clinical features, metabolic disorders and management of Marasmus and Kwashiorkor, Nutritional anemias.

Nutrient-Nutrient Interactions: Mineral Interactions; Interactions of Vitamins with Minerals-Vitamin Interactions, Macronutrient Interactions and Amino Acid Interactions

UNIT 4

Obesity: Definition and classification. Genetic and environmental factors leading to obesity. Obesity related diseases and management of obesity. Role of leptin in regulation of body mass.

Clinical nutrition: Causes and role of nutrition in prevention & treatment of dental caries, hyperlipidemia, atherosclerosis, rheumatic disorders and inherited metabolic disorders

(Phenylketonuria, MSUD, homocystinuria, galactosemia, gout and diabetes mellitus); Eating disorders (Anorexia Nervosa, Bulimia Nervosa, Binge-Eating Disorder).

Suggested Readings:

1. Textbook of Medical Biochemistry **By** MN Chatterjea and Rana Shinde, Jaypee Brothers.
2. Essentials of Food and Nutrition Vol I & II, **By** M. Swaminathan. Bangalore Printing and Publishing Co. Ltd.
3. Modern Nutrition in Health and Diseases, **By** Maurice E Shils and Vernon Robert Young, 7th Ed., Pub: Lea & Febiger.
4. Handbook of Nutrition and Food 2nd Ed., **By** Carolyn Berdanier, Johanna Dwyer and Elaine Feldman, CRC Press
5. Nutritional Biochemistry (Hardcover) **By** Tom Brody. Academic Press.
6. Nutritional Biochemistry (Paperback) **By** S Ramakrishnan and S. Venkat Rao. TR Publications
7. Food and Nutrition **By** Anita Tull. Oxford University Press.
8. Nutritional Biochemistry and Metabolism: With Clinical Applications (Hardcover) **By** Maria C. Linder. Publisher: Appelton and Lange
9. Introduction to Nutrition and Metabolism (Paperback) **By** David A. Bender. CRC Pre-ss Inc.
10. Principles of Human Nutrition **By** Martin Eastwood. Publisher: Wiley Blackwell.
11. Human Nutrition with CD-ROM (Paperback) **By** Catherine Geissler and Hilary Pow-ers. Publisher: Churchill Livingstone.
12. Food Science: The Biochemistry of Food and Nutrition (Hardcover) **By** Kay Yockey Mehas and Sharon Lesley Rodgers. Publisher: McGraw-Hill/Glencoe.
13. Lehninger Principles of Biochemistry 5th Ed **By** David L. Nelson and Michael M. Cox, WH Freeman and Company.

BC 303: Clinical Biochemistry

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All questions to carry equal marks.

Max. Marks: 80

Max. Time: 3 hrs

UNIT 1

Disorders of carbohydrate metabolism: Diabetes mellitus, glycohemoglobins, hypoglycemia, galactosemia and ketone bodies. Various types of glucose tolerance tests. Glycogen storage diseases.

Lipidosis and multiple sclerosis. Causes and diagnosis of the disorders of HDL-cholesterol, LDL-cholesterol and triglycerides.

Inborn errors of metabolism:

- a) **Disorders of amino acid metabolism-** Phenylalanemia, homocystinuria, tyrosinemia, MSUD, phenylketonuria, alkaptonuria, albinism and aminoacidurias.
- b) **Disorders of nucleic acid metabolism-** Disorders in purine/ pyrimidine metabolism.

UNIT 2

Evaluation of organ function tests: Clinical assessment of renal, hepatic, pancreatic, gastric, intestinal and thyroid functions. Clinical importance of bilirubin.

Diagnostic enzymes: Principles of diagnostic enzymology. Clinical significance of aspartate aminotransferase, alanine aminotransferase, creatine kinase, aldolase and lactate dehydrogenase. Enzyme tests in determination of myocardial infarction. Enzymes of pancreatic origin and biliary tract.

UNIT 3

Hormonal disturbances: Protein hormones (anterior pituitary hormones, posterior pituitary hormones), steroid hormones, adrenocorticosteroids, and reproductive endocrinology. Disturbances in thyroid function.

Disorders of mineral metabolism: Hyper/Hypokalemia, Hyper/Hyponatremia, Hypercalcaemia, hypocalcaemia, hypophosphataemia and hyperphosphataemia.

UNIT 4

Biochemical aspects of hematology: Disorders of erythrocyte metabolism & membrane, hemoglobinopathies, thalassemias, thrombosis, porphyrias and anemias. Laboratory tests to measure coagulation and thrombolysis.

Detoxification in the body: enzymes of detoxification, polymorphism in drug metabolizing enzymes. Mechanism of drug action and channels of its excretion. Disorders of trace elements.

Suggested Readings:_____.

1. Textbook of Medical Biochemistry **By** MN Chatterjea and Rana Shinde, Jaypee Brothers.

2. Lehninger Principles of Biochemistry 5th Ed **By** David L. Nelson and Michael M. Cox, WH Freeman and Company.
3. Davidson's Principles and Practice of Medicine: A Textbook for Students and Doctors (Hardcover) 15th Ed **By** LSP Davidson, J MacLeod and CRW Edwards. Publisher: Churchill Livingstone.
4. Medical Biochemistry (Paperback) **By** John W. Baynes and Marek Dominiczak. Publisher: Mosby.
5. Clinical Biochemistry: An Illustrated Colour Text (Paperback) 3rd Ed **By** Allan Gaw, Michael Murphy, Robert Cowan, Denis O'Reilly, Michael Stewart and James Shepherd. Publisher: Churchill Livingstone.
6. Review of Medical Physiology (Lange Basic Science) (Paperback) **By** William F. Ganong. Publisher: McGraw-Hill Medical
7. Harper's Biochemistry (Lange Medical Books) (Paperback) **By** Robert K. Murray, Daryl K. Granner, Peter A. Mayes and Victor W. Rodwell. Publisher: Appelton and Lange.
8. Clinical Biochemistry **By** Richard Luxton. Scion Publishing Ltd.
9. Principles of Medical Biochemistry: With STUDENT CONSULT Online Access (Paperback) **By** Gerhard Meisenberg and William H. Simmons. Publisher: Mosby.

BC 304: Microbial Biochemistry

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All questions to carry equal marks.

Max. Marks: 80

Max. Time: 3 hrs

UNIT 1

Methods of classification of microorganisms, general characteristics of main groups of microorganisms. Mycoplasmas. Gram +ve and Gram -ve bacteria with structure and functions of peptidoglycan in them. Functions of polymeric components in outer membrane and acidic polymers in Gram -ve bacteria.

Different phases of microbial growth and physical conditions required. Culture media and isolation of pure bacterial cultures. Staining methods for bacteria. Quantitative measurement of bacterial growth.

UNIT 2

Genetic recombination in bacteria (Transformation, transduction and conjugation). Transcription and translation in bacteria. Synthesis of peptidoglycan. Mechanism of action of anti-bacterial antibiotics.

Biosynthesis of aspartate family amino acids, aromatic amino acids and histidine. Stickland reaction. Synthesis pathways of coenzyme A, folate, riboflavin, NAD(P) and cobalamins in bacteria.

UNIT 3

Protein export pathways, generation of energy (ETC in aerobic/sulfur bacteria, autotrophic CO₂ fixation pathways), Oxidative reactions in methylotrophs. Microbial stress responses (genetic response to osmolality, modifications by facultative microbes, formate nitrate regulation, oxidative/pH/thermal stresses).

Specific alternative carbohydrate pathways (Entner Doudoroff Pathway, phosphoketolase pathway and anaerobic TCA). Fermentation pathways, Utilization of galactose, maltose, sorbose & mannitol. Metabolism of aromatic hydrocarbons.

UNIT 4

Virus structure including viral proteins, virus classification and lytic/lysogenic life cycles in viruses. Virus-induced changes in cells, methods of assay of viruses.

Replication of RNA viruses- negative strand (VSV), positive strand (polio) and retroviruses (HIV). Replication of DNA viruses (Adenovirus or SV40).

Suggested Readings:_____.

1. Microbiology: An Introduction, Eighth Edition **By** Gerard J. Tortora, Berdell R. Funke, Christine L. Case. Pearson Education.
2. Fundamentals of Microbiology **By** I. Edward Alcamo. Benjamin-Cummings Pub Co.

3. Microbial Life (Hardcover) **By** Jerome Perry, James Staley and Stephen Lory. Pub: Sinauer Associates Inc.
4. Microbiology: Concepts and Applications (Hardcover) **By** MJ Pelczar, ECS Chan and NR Krieg, McGraw-Hill.
5. Microbiology (Hardcover) **By** Lansing M. Prescott, John P Harley and Donald A. Klein. Publisher: McGraw Higher Education.
6. Principles of Microbiology **By** Ronald M. Atlas
7. Microbiology **By** BD Davis, R Delbecco, HM Eisent and HS Ginsberg. Medical Division, NY.
8. Microbial Biochemistry (Hardcover) **By** ML Srivastava, Alpha Science Intl Ltd.
9. Microbial Biochemistry (Hardcover) **By** GN Cohen, Publisher: Springer.
10. Microbial Physiology **By** Albert G. Moat, John Watkins Foster, Michael P. Spector. Publisher: John Wiley & Sons.
11. Cofactor Biosynthesis: A Mechanistic Perspective, Volume 61 (Vitamins and Horm-ones) (Hardcover) **By** Gerald Litwack, Tadgh Begley. Publisher: Academic Press.
12. Principles of Virology: Molecular Biology, Pathogenesis and Control. **By** SJ Flint, LW Enquist, RM Krug, VR Racaniello and AM Skalka. ASM Press.
13. Fundamentals of Molecular Virology **By** Nicholas H. Acheson. John Wiley & Sons.
14. Basic Virology (Paperback) **By** Edward K. Wagner (Author), Martinez J. Hewlett, David C. Bloom and David Camerini. Publisher: WileyBlackwell

BCE 305: Bioinformatics

Note: Que. 1 will be compulsory, of 12 marks and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit, each carrying 14 marks each and candidate will have to attempt one question from each unit. Overall, three questions to be attempted.

Max. Marks: 80

Max. Time: 3 hrs

OPEN ELECTIVE

UNIT 1

Computer system design- essential components and working. Input/output and storage devices. Number Systems in computing language.

The Virtual Library: Tools and resources in NCBI. Searching 'Medline' on PubMed system from NCBI. Science Citation Index and Current contents. *Introduction of biological databases*- types (relational & object-oriented). Primary, secondary & specialized databases.

UNIT 2

Types of databases- Nucleotide sequence database, EMBL, Genebank, Unigene, Genome biology, Protein dBase (Swiss-prot & Trembl and motif) and 3D structure databases (PDB, SCOP, Cath, Genecards, SRS & Entrez). Protein sequence databases.

Patents and searching of patent databases. Computational approaches for gene identification, ORF and Human Genome Project. Overview of sequence assembly.

UNIT 3

Basics of sequence analysis- Dot matrix method, Needleman-Wunsch Algorithm and Smith-Waterman algorithm, Alignments using BLAST and FASTA.

Multiple Sequence Alignment- CLUSTAL-X and CLUSTAL-W, Applications of multiple sequence alignment (PSSM and Markov/Hidden Markov models).

Analysis tools- Analysis by TreeView, Genedoc and Lasergene.

Phylogenetics- construction by distance based methods, character based methods

UNIT 4

Protein Structure Prediction in Bioinformatics- Ab initio based methods, Homology based methods, prediction with neural networks

Secondary structure prediction- Globular and transmembrane proteins. Coiled coil prediction, Gene and promoter prediction

Protein structure comparison- intermolecular and intramolecular methods

Standards and approaches for functional genomics

Suggested Readings: _____.

1. Computer Fundamentals: Concepts, Systems and Applications **By** PK Sinha. BPB Publications.

2. Computer Fundamentals and Programming in C **By** JB Dixit. University Science Press.
3. Computer fundamentals and programming in C **By** Amiya Kumar Rath, Alok Kumar Jagadev and Santosh Kumar Swain. Scitech Publications.
4. Computer Fundamentals (Paperback) **By** Ashok Arora, Shefali Bansai and Shefali Ban-sal. Publisher: Excel Books.
5. Discovering Computers: Fundamentals (Paperback) **By** Gary B. Shelly. Publisher: Course Technology.
6. Discovering Computers: Fundamentals, Fourth Edition (Shelly Cashman) (Paperback) **By** Gary B. Shelly Thomas J. Cashman and Misty E. Vermaat. Publishers: Course Technology
7. Computer Fundamentals: Architecture and Organization (Paperback) **By** B. Ram. Publisher: New Age Publications (Academic)
8. Essential Bioinformatics (Paperback) **By** Jin Xiong. Cambridge University Press.
9. Bioinformatics: Methods & Protocols **By** Stephen Misener and Stephen A. Krawetz, Humana Press.
10. Essentials of Bioinformatics **By** Irfan Ali khan and Atiya Khanum. Publisher: Ukaaz Publications.
11. Bioinformatics: Sequence and Genome Analysis (Hardcover) **By** David W. Mount. Cold Spring Harbor Laboratory Press
12. Introduction to Bioinformatics (Paperback) **By** Arthur M. Lesk. Oxford Univ Press.
13. Introduction to Bioinformatics: A Theoretical and Practical Approach (Paperback) **By** David Womble, Stephen A. Krawetz and David D. Womble. Humana Press Inc., U.S.
14. Applied Bioinformatics: An Introduction (Paperback) **By** Paul M. Selzer, Richard Marhofer and Andreas Rohwer. Publisher: Springer-Verlag Berlin and Heidelberg GmbH & Co. K.

BC 306: Lab Course III

Max. Marks: 100

Max. Time: 3 hrs

Culture media; preparing & dispensing culture media establishing pure cultures. Preparation of wet mount, mobility test –Simple stain-Gram's stain-Acid Fast stain-Capsule stain.

Physiological reaction of bacteria –Catalase test –Coagulates test –Oxidase Test- Nitrate test –Carbohydrate Fermentation test – IMVIC test –TSI test, Antibiotic sensitivity test- Qualitative: Kirby Bauer's methods, Quantitative, MIC

Blood sugar, Urea, Uric acid, Creatinine, Bilirubin, Cholesterol, triglyceride, High Density Lipoproteins, Low Density Lipoproteins, Very Low Density Lipoproteins.

Estimation of bicarbonate in beverage, and iron, copper and vitamin C in food items

Chloroplast Isolation; Estimation of Chlorophyll; Plant Physiology tests; Metal content estimations; Plant Metabolic Studies

Bioinformatics softwares- use of BLAST, CLUSTAL, Genedoc and Treeview for sequence comparison.

BC 401: Biostatistics

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 mark(s). Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All questions to carry equal marks.

Max. Marks: 80

Max. Time: 3 hrs

UNIT 1

Significance and limitations of statistical calculations, Measures of central tendency (mean, median, mode) and dispersion (standard deviation, CV and mean deviation). Objectives and design of experiment- experimental unit, identifying variables, replications & controls, treatment structure and design structure.

UNIT 2

Sampling techniques. Probability theory (Addition and multiplication theorems), random variables & probability distributions (discrete and continuous), Point and interval estimation, linear regression. Statistical evaluation of results- Hypothesis testing, interpretation of statistic for analysis of error.

UNIT 3

Parametric tests- ANOVA, F-test, t-test, z-test, correlation coefficient. Measurement of skewness and kurtosis. Relative and cumulative frequency distributions. Graphical analysis of data and presentation of results. Research design- Meaning and need for research design, features of good design.

UNIT 4

Non-parametric tests- Chi-square test, Wilcoxon signed rank test, Wilcoxon rank sum test (Mann-Whitney U test), Sign test, Runs test, Kruskal-Wallis H Test, Spearman's rank correlation, Tukey-Duckworth test and Friedman test.

Suggested Readings:

1. Biostatistics **By** PN Arora and PK Malhan, Himalaya Publishing House.
2. Experimental Design and Data Analysis for Biologists **By** Gerry P. Quinn and Michael J. Keough. Publisher: Cambridge University Press.
3. Principles of Biostatistics (with CD-ROM) (Hardcover) **By** Marcello Pagano and Kimberlee Gauvreau. Publishers: Duxbury Press
4. Biostatistics: Experimental Design and Statistical Inference (Hardcover) **By** James F. Zolman. Oxford University Press.
5. Intuitive Biostatistics **By** Harvey Motulsky. Publisher: Oxford University Press

BC 402: Methods in Molecular Biology

Note: Que. 1 will be compulsory and will cover the entire syllabus in the form of short questions of 1 or 2 marks. Que. 2 to 9 will include two questions from each unit and candidate will have to attempt one question from each unit. Overall, five questions to be attempted. All questions to carry equal marks.

Max. Marks: 80

Max. Time: 3 hrs

Unit 1: Nucleic acid and Protein characterization

Methods of distinguishing double and single stranded DNA- SSB protein binding, S₁ nuclease digestion and ethidium bromide staining. Analysis of chromatin by micrococcal nuclease, chromatin immunoprecipitation, STAGE, chromosome conformation capture and triton/acetic/urea PAGE. Microarray analysis of mRNA.

Analysis of protein phosphorylation by phosphoamino acid analysis, unlabeled proteins, enzymatic techniques, exogenous substrates, phosphopeptide mapping and permeabilization strategies. Identification of sugars in glycoproteins by metabolic radiolabeling, chemical labeling and lectin analysis.

Unit 2: Gene identification and Mutagenesis

Identification of gene by nucleic acid hybridization, immunoscreening, screening by function, screening by interaction, phage display and two hybrid screening. High density gene arrays and phenotypic microarray.

Creation of mutation by primer extension mutagenesis, strand selection methods, cassette mutagenesis, PCR based mutagenesis, QuickChange mutagenesis and random mutations in specific genes

Unit 3: Cloning Methods

Strategies for cloning in plasmid vectors: their purification and characterization. Identification of bacterial colonies that contain recombinant plasmids. Cloning by Bacteriophage λ and M13 vectors.

Cloning in cosmid vectors. Construction of Genomic DNA libraries in cosmid vectors. Agarose gel electrophoresis, detection and extraction of DNA from gels. Construction and analysis of cDNA- protocols and strategies for cDNA cloning.

Unit 4: Probe-mediated Screening and protein-protein Interactions

Preparation of radiolabeled DNA and RNA probes. Synthetic oligonucleotides probes. Introduction and expression of cloned Genes in cultured cells. Screening expression with antibodies and oligonucleotides.

Significance of protein-protein interaction technology, two-component systems for protein interactions, analysis by Bait-LexA fusion protein, GST fusion proteins, coimmunoprecipitation and green fluorescent protein. Use of FLIM-FRET and SPR in protein interaction analysis

Suggested Readings:_____.

1. Molecular Cloning: a laboratory manual (Vol 1, 2 & 3) **2nd Ed. By** T. Maniatis, EF Fritsch and J. Sambrook. Cold Spring Harbor Laboratory Publications, NY.
2. Molecular Cloning: a laboratory manual (Vol 1, 2 & 3) **3rd Ed. By** J. Sambrook and DW Russel. Cold Spring Harbor Laboratory Publications, NY
3. Current protocols in Molecular Biology **By** Frederick M. Ausubel, Roger Brent, Robert E. Kingston, David D. Moore, J.G. Seidman, John A Smith and Kevin Struhl. John Wiley & Sons Ltd.
4. Analysis of Genes and Genomes **By** Richard J Reece. John Wiley & Sons Ltd.
5. Genomics: Fundamentals and Applications. **By** S Choudhuri and DB Carlson. Informa Healthcare.
6. Gene and Probes: A practical approach series **By** BD Hames and SJ Higgins. Oxford university Press.
7. Non-isotopic methods in Molecular Biology **By** ER Levy and CS Herrington. Oxford University Press.